**3GPP TSG RAN WG1 #104-e R1-2102112**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#6 for multi-beam enhancement: Round 3B

**Document for:** Discussion and Decision

## Introduction

In this summary, the term “item 1” refers to the first item in the Rel.17 NR FeMIMO WID, i.e. multi-beam enhancement:

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| * Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:   + Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility and/or a larger number of configured TCI states:     1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA     2. Unified TCI framework for DL and UL beam indication     3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)   + Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection |

## Summary and proposals

The summary and proposals are based on the content of the previous FL summaries R1-2101185 (preparation) and R1-2101856 (round 1).

### Issue 1 (Rel.17 unified TCI framework)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.11 | TCI State pool for CA  Alt1: Shared among CCs  Alt2: Individually configured per CC | **Alt1 (14)**: Spreadtrum, Xiaomi, ZTE, vivo, MTK, Intel, Sony, NTT Docomo, Samsung, Qualcomm, Lenovo/MoM, Ericsson (UL TCI), IDC  **Alt2 (12)**: OPPO, Nokia/NSB, CMCC, Huawei/HiSi, CATT, APT, TCL, Ericsson (DL TCI), Futurewei, LG  **QCL Type-A implicitly determined based on CC:** Intel, Samsung, MTK, CATT, ZTE |
| 1.12 | For separate TCI, UL TCI state pool  Alt1: Shared pool with joint/DL TCI state  Alt2: Separate pool | **Alt1 (11)**: Spreadtrum, Xiaomi, ZTE, CATT, vivo, MTK, Intel, Convida, Qualcomm, Samsung, NTT Docomo  **Alt2 (16)**: Futurewei, OPPO, Lenovo/MoM, Nokia/NSB, CMCC, Ericsson, Huawei/HiSi, AT&T, Sony, Lenovo/MoM, APT, CATT |

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| Previous agreements:   * FFS: TCI state pool for CA   + Opt-1: sharing a single RRC TCI state pool for the set of configured CCs, e.g., cell-group TCI state pool, or reuse TCI state pool for PDSCH in a reference cell; A CC ID for QCL-Type A RS is absent in a TCI state, and the CC ID for QCL-Type A RS is determined according to a target CC of the TCI state.     - FFS: Whether it is possible that a single TCI state in the pool includes all source RSs from different CCs   + Opt-2: configuring RRC TCI state pool per individual CC |

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| Action: Please answer the questions below.   1. TCI state pool for CA (for common signaling of TCI state ID across CCs):    1. Since QCL Type-A reference must be CC-specific (unlike QCL Type-D), Alt1 can work only if QCL Type-A reference can be inferred via other means, e.g. “implicitly determined based on CC” (there might be other means). Could Alt1 proponents explain how QCL Type-A reference be obtained?    2. For UL TX spatial reference, is there any advantage of Alt2 over Alt1 (since Alt1 seems a natural choice)? 2. TCI state pool for separate DL/UL TCI: Considering the supported source RS types for joint TCI are a subset of those for UL-only TCI (since joint TCI applies to both DL and UL),    1. How would Alt1 overcome this limitation (otherwise the choice of UL TCI source RS types for Alt1 would be limited to that of joint TCI)?    2. Is there any advantage of Alt1 over Alt2 that justifies the potential drawback in 2a?   Goal: Finalize the proposal to be ready for endorsement |

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| **Proposal 1.1**: On Rel.17 unified TCI framework, support the following TCI state pool design for carrier aggregation (CA):   * A single/shared RRC TCI state pool for the set of configured CCs for DL QCL reference (of all applicable types) and UL TX spatial reference   + For QCL Type-A, a CC ID for QCL-Type A source RS can be absent in a TCI state.   + When the CC ID for QCL-Type A source RS is absent in the TCI state, the CC ID for QCL-Type A source RS is determined according to a target CC of the TCI state and configured with source RS ID     - For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeA RS source ID to locate the corresponding QCL Type-A source RS   + Note: When RRC TCI state pool is configured per individual CC, reuse Rel-16 cross-CC simultaneous TCI state ID update * FFS: Whether it is possible that a single TCI state in the pool includes all source RSs from different CCs   **Proposal 1.2**: On Rel.17 unified TCI framework, in case of separate DL/UL TCI, decide between the following two alternatives for UL TCI state pool design upon the conclusion of source RS type support for DL QCL reference and UL TX spatial reference:   * Alt1. UL TCI shares the same TCI state pool as joint DL/UL TCI * Alt2. UL TCI uses a separate TCI state pool from joint DL/UL TCI   Note: By previous agreements, DL TCI shares the same TCI state pool as joint DL/UL TCI. |

Table 2 Inputs: issue 1

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| **Company** | **Input** |
| Moderator | Please provide inputs for the questions |
| Apple | 1a: It is true that there could be a problem for QCL-TypeA for Alt1.  1b: It seems not. I am not sure whether power control could be a problem.  2a: Indeed, some rules need to be defined for Alt1, like TCI selection for CORESET0, where only the first 64 valid TCI states can be indicated  2b: I guess the potential advantage could be RRC overhead reduction. gNB does not need to configure the same RSs in different TCI states. |
| CATT | 1a: Agree that QCL-typeA RS derivation may need to be addressed for alt-1.  1b: It is preferable the CA framework is band-agnostic at least from RAN1 perspective. For (future potential) inter-band application, common pool may mandate the same QCL-typeD RS (assuming same TCI-ID) for each CC and same DL/UL spatial filter for CCs in different bands, thereby limiting its use case. Alt-2 avoids this issue.  2a:  2b: Unclear. We don’t think RRC overhead is a major optimization area. |
| APT | 1a. indeed, how to derive QCL-typeA for Alt1 is unclear to us.  1b.  2a. it is not clear if Alt-1 can be applied for separate DL/UL case.  2b. similar to CATT, we don’t think RRC overhead is an issue here. |
| ZTE | 1a: The straight-forward solution for deriving QCL Type A RS is: when a CC ID for QCL-Type A RS can be absent in a TCI state in a reference cell, the CC ID for QCL-Type A RS is determined according to a target CC of the TCI state.   * In our opinion, this way of “applying the same QCL Type-A RS ID to the CCs in the same CC group” in Alt-1 seems to be similar to “applying the same activated TCI state ID to the CCs in the same CC group” in Alt-2. The only enhancement of Alt-1 over Alt-2 is to change the level/requirement of same ID from TCI state to QCL Type-A RS resource, and huge RRC overhead can be saved accordingly.   1b: It seems not. If going with Alt-2, the rule of PL RS determination should be considered to satisfy the rule of up to 4 PL RS(s) for a UE.  2a: Introducing SRS for BM into TCI state is a natural solution for handling this limitation. Alternatively, we can further support to have association signalling between TCI state and SRS. When is applied, the SRS is used for determining spatial filter of UL transmission, and herein we can have a condition that the SRS should share the same spatial domain filter as QCL-TypeD RS in the TCI state, if any.  2b: RRC overhead can be saved significantly, especially considering cross-CC case as mentioned in 1a and 1b. |
| LG | 1a: agree that this is the problem of Alt1  1b: UL TCI can include other than beam RS such that power/timing control related in this or later releases. So, Alt2 is more futureproof design. |
| MediaTek | Q1a: Support of Alt1 is natural since we already agree the following in the previous meeting:  Previous agreements:   * The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs   NW usually configures different TCI states for different gNB beams, where each TCI state associates one or two source RSs transmitted from a same NW beam. For Alt2, when the TCI states with a same ID are configured for a set of CCs, QCL-TypeD source RS shall be the same on one of the CCs, which means TCI states with a same ID configured in the CCs are associated with a same NW beam.  For Alt1**, a CC ID for QCL-TypeA source RS can be absent in a TCI state of the TCI state pool and the CC ID for QCL-TypeA RS is determined according to the target CC.** If NW can properly allocate the RS IDs for QCL-TypeA source RS, it is possible that a single TCI state can include all the required source RSs from the CCs. Thus, Alt1 is a better choice to avoid unnecessary configuration overhead and required UE memory.  For UL PC, we don't think this will be an issue in Alt1.  Q1b: For UL, there is no QCl-TypeA RS issue. Thus, it natural to use Alt1.  Q2a: For Alt1, we don't think that the TCI states for joint DL/UL beam indication has to be a subset of those for UL-only beam indication. NW can configure a pool of TCI states for different gNB beams, and joint DL/UL beam indication and UL-only beam indication can use the same pool of TCI states. If a TCI state is indicated/activated/configured for joint DL/UL beam indication, then common QCL and UL spatial Tx filter can be determined according to the previous agreement. If a TCI state is indicated/activated/configured for UL-only beam indication, UL spatial Tx filter still can be determined from the RS of DL QCL Type D in the TCI state.  Q2b: Separate pools are not necessary since NW only has to configure a pool of TCI states each corresponds to a gNB beam. Alt2 will cause unnecessary configuration overhead and required UE memory.  **Possible proposal:**  On Rel.17 unified TCI framework, UL TCI of separate DL/UL TCI and joint DL/UL TCI share a same pool of TCI states   * For UL TCI of separate DL/UL TCI, UL spatial filter is derived from the RS of DL QCL Type D |
| TCL | 1b: Our view is similar to that of LG;  2b: For Alt 2, gNB may need to configure multiple TCI states, which would lead to latency and signaling overhead. |
| Xiaomi | 1a, share same view as ZTE and MTK  1b, no  2a, we don’t see the limitation here. We think TCI state in the joint TCI state pool is enough for separate UL-only TCI because of beam correspondence. Even with MPE impact, two different TCI states in joint TCI state pool can be indicated for separate DL TCI state and separate UL TCI state respectively.  2b, the advantage is the lower RRC signaling overhead with Alt 1. |
| Docomo | 1a: Firstly, we would like to clarify that QCL Type-D RS also must be CC-specific for some cases (As shown below, it says QCL Type-A RS and QCL Type-D RS should be the same resource). QCL Type-D RS can be CC common or CC specific. So, this question (and potential FL proposal) should also cover QCL type Type-D RS (if CC specific).  ----  For the DM-RS of PDCCH, the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):  - 'QCL-TypeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'QCL-TypeD' with the same CSI-RS resource, or  - 'QCL-TypeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'QCL-TypeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or  - 'QCL-TypeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter trs-Info and without higher layer parameter *repetition* and,when applicable, 'QCL-TypeD' with the same CSI-RS resource.  ----  The necessary information for the target cell is combination of RS index and cell index. We can assume the same RS index is applied for each CC for QCL type A RS (i.e. if unified TCI is TRS#2, TRS#2 of CC#1 is used for QCL type A on CC#1, and TRS#2 of CC#2 is used for QCL type A on CC#2, and so on). We don’t need to explicitly configure the CC index for type A. On the other hand, QCL type D RS can be CC common or CC specific. Hence, we should be able to configure CC index for QCL type D RS.  One example of RRC structure is:  Unified TCI state (common for CCs):{   * QCL type A RS index for each CC = {RS#1, RS#2, …, RS#64} * QCL type D RS index for each CC = {RS#1’, RS#2’, …, RS#64’} * Cell index of QCL type D RS = {target cell, CC#1, CC#2, …}   }  Following figure illustrates the example of following configuration:   * QCL type A RS index for each CC = RS#2 * QCL type D RS index for each CC = RS#2’ * Cell index of QCL type D RS = CC#1     1b: We think no. |
| Ericsson | 1a: We do not see a good solution to this. The solution that ZTE mentions is indeed similar to the cross-CC TCI state activation. That solution has the drawback that the configurations on the carriers need to be identical. For TCI states, this restriction can be handled, but for TRS, this would mean a tougher restriction.  1b: Can’t see any  2a: One solution would have been not to allow SRS for BM for UL TCI, but that would require reverting agreement  2b: No. The RRC overhead issue is complicated, and the design should be left to RAN2. |
| vivo | 1a: The QCL Type-A reference is implicitly determined based on target serving CC.  1b: there seems to be no advantage.  2a: Application of TCI state for UL may not necessarily to be applied for DL through configuration or implementation.  2b: save RRC overhead. |
| Sony | 1a: same view with ZTE/MTK that QCL-TypeA RS without CC index configured in TCI state can be a valid solution. Moreover this solution is depicted in Docomo’s figure.  1b: Alt.2 could be more flexible than Alt.1 with per CC configured TCI state pool which comes at the cost of large signaling overhead. If PC and/or TA parameters are included in TCI states (pending issue), but not associated with TCI state, Alt.2 may result in more proper UL power control and/or time advancing.  2a:  2b: |
| Fraunhofer IIS/HHI | 2a: This is one issue that may leave Alt-1 with more spec impact than Alt-2. Specific procedures to classify UL and DL TCI states and its impact on existing TCI state based procedures are a concern. Although there are merits to both Alt-1 and 2, due to such issues we slightly prefer Alt-2 over Alt-1. |
| Nokia | 1a: We agree that Alt1 needs further clarification on how to configure QCL type-A  1b: Sharing similar view with CATT. Same TCI across multiple/all CCs would not be valid always. So we expect Alt 2 is more general approach.  2a:  2b: We don’t see clear benefits. But may less overhead on RRC configuration can be achieved. |
| Samsung | 1a: Indeed, QCL Type-A must be CC specific. As described by several companies, the cell index for QCL Type-A can be absent from the TCI state, and inferred by the target cell. QCL-Info for QCL Type-D can include a cell index to identified the cell of the source RS.  1b: For UL Tx spatial reference, it would seem natural to have the same beam applied to a group of cells. This saves RRC configuration overhead – this is advantage of Alt1 over Alt2.  2a: The norm for beam indication is to have the same beam for DL and UL, i.e. joint beam indication. Separate beam indication is for handling special cases, which we believe are not frequent. Given this view, we don’t think that it is prudent to over design the system for the special case especially when there is downside associated with this overdesign (see answer to 2b). If we allow an UL TCI state for separate DL/UL beam indication to have a different source RS type there should be justification for that. We would like the proponents of a separate UL TCI state pool for the separate DL/UL beam indication to state the justification of having a separate source RS type.  2b: Alt1 has less RRC overhead over Alt2. Alt1 can potentially simplify the UE implementation as the same source RS Type is used for separate and joint beam indication. |
| OPPO | 1a: That is the reason why we prefer Alt2.  1b: we do not see benefit of Alt1. Alt2 is a more general method and it does not need changing the TCI state framework.  2a/2b: Using common pool for separate DL and UL TCI state would increase the high layer signalling overhead in some aspect. |
| Qualcomm | For 1a,   * Alt1 works as below: Each configured TCI state is applied to multiple CCs. The TypeA RS in the configured TCI state can be only configured with RS ID. For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + TypeA RS ID to locate the corresponding TypeA RS.   For 1b   * No advantage of Alt2 over Alt1 if all CCs share the same UL analog beam.   For 2a   * Alt1 has no such issue to our understanding. In our view, all types of TCI share the same pool. For each configured TCI state, there can be an implicit/explicit indicator on its TCI type, and corresponding configured source RS types should be consistent with the indicated TCI type.   For 2b  Alt1 has advantage that DCI only needs to indicate TCI ID and does not need to indicate which type. Alt2 may have to indicate both TCI ID and type, since same TCI ID can be used by multiple types |
| Lenovo/MoM | 1.a: Agree that QCL-typeA RS derivation may need to be addressed for alt-1.  1.b: There is no advantage of Alt2 over Alt 1 for UL spatial info since QCL-TypeD can be in another CC.  2.a: Alt 1 will need more bits in DCI because more TCI states are needed from joint DL/UL TCI pool.  2.b: There is no advantage of Alt 1 over Alt 2. |
| Intel | Q1a: Alt 1 can work as QC mentioned with implicit determination of Type A RS.  Q1b: No obvious advantage. Alt2 may lead to high configuration overhead. Unless use case is clear, prefer to simplify configuration.  Q 2a: Shared pool ensures that current beam indication framework can be reused. In the case of separate UL only beam indication, if a source RS which is applicable for UL only is configured, this would implicitly indicate to the UE that the usage of the configured TCI state is for UL only TCI. If the UL only RS is part of the common RSs also applicable to joint DL/UL TCI there is no issue. Additionally, MAC-CE indication (during codepoint configuration) can also be used to differential UL-only TCI from joint DL/UL TCI for shared pool.  Q2b: Separate TCI state pool will additionally need to have usage indication design to let the UE know which pool the TCI state ID in DCI is addressing. Additionally, to support Alt. 2 many configurations may need to be duplicated. Alt. 1 simplifies this considerably. |
| AT&T | 2.a With the current source RS types supported for UL TC versus joint TCI, it is an issue for Alt. 1  2.b No clear benefits of alt. 1 over alt. 2. |
| Futurewei | 1a: Agree that is an issue of Alt 1.  1b: We do not see benefit of Alt 1 over Alt 2.  2a: SRS is one of the source RS for UL TCI state, so the UL TCI state could be different from the joint/DL TCI state. In Alt 1, if both the join TCI and UL TCI states are combined in a joint TCI pools, the number of TCI states in the joint TCI pool will be larger than that of the separate DL/UL TCI pools. The MAC CE that is used to select and activate a subset of TCI states from the joint pool needs to be changed to accommodate the larger number of TCI states.  2b: We do not see advantage of Alt 1 over Alt 2. |
| Moderator | Re Q1a, based on the above inputs, despite (slight and strong) preference on Alt2 from almost half of interested companies, there doesn’t seem to be a compelling reason why Alt1 is problematic for DL QCL Type-A. With “**a CC ID for QCL-TypeA source RS can be absent in a TCI state of the TCI state pool and the CC ID for QCL-TypeA RS is determined according to the target CC**” a good NW implementation (most likely) can still properly allocate QCL Type-A RS IDs across CCs with a common TCI state ID (note: Several companies point out that common state ID doesn’t imply common state). Essentially the same mechanism as QCL Type-D can hold. **Alt2 proponents**, please see detailed comments from, e.g. ZTE, MediaTek, NTT Docomo, Qualcomm. Some companies (e.g. Ericsson) find this too restrictive for QCL Type-A.  Re Q1b, some companies prefer a structure agnostic to bands. Other argue some potential PC/TA issue could make Alt2 slightly more flexible. Other than that, Alt1 seems to be a natural choice according to most companies (no other tangible advantage of Alt2 over Alt1).  Re Q2a, from the above comments, it’s unclear that the above limitation imposed by Alt1 can be overcome especially if SRS for BM is not supported as a source RS type for DL TCI (TBD in RAN1#104bis-e). It is also contingent on some other potential source RS type(s) (also TBD in RAN1#104bis-e). In essence, unless all the source RS type(s) applicable for UL are also applicable for DL, the benefit of Alt1 over Alt2 is superseded by this limitation (FL perspective).  Re Q2b, most companies see RRC overhead reduction as the main/only benefit of Alt1 over Alt2.  Weighing on the above technical inputs from companies, I’ll try to see if proposal 1.1 and 1.2 are acceptable. |
| OPPO2 | Do not support Proposal 1.1. Single TCI state pool for CA would impose extra restriction on configuration and scheduling. Do not see there is any issue with separate pool for each individual CC. It is preferred to keep the same design as rel15/16  Re proposal 1.2: the issue is how to configure TCI state pool for separate TCI states. The why do we discuss the pool for separate UL TCI state vs joint TCI state |
| Huawei, HiSilicon | Issue 1.12: We are not sure why the number of supporters of Alt-1 is increased after CATT is moved to Alt-2. Maybe it is a typo.  {Mod: Yes, sorry, thanks for spotting, fixed}  Proposal 1.1: We share similar view as Ericsson that sharing a single RRC TCI state pool across CCs is overly restrictive for QCL-TypeA. And we share similar view as Apple/LG that sharing a single RRC TCI state pool across CCs may have unexpected impacts on uplink power/timing control, which is currently designed per CC. Also, if separate TCI state pools are used for DL TCI and UL TCI, the main bullet of ‘a single/shared RRC TCI state pool’ may not hold any more.  Proposal 1.2: According to the conclusion agreed in the first GTW session, in terms of functionality (targeted channels and source RS type), joint DL/UL TCI appears to be a sub-set of DL TCI in our understanding(?). |
| Docomo | Support Proposal 1.1. But, we are wondering whether we will discuss QCL type D RS as another proposal, because the proposal only covers QCL type A RS.  {Mod: thanks, added clarification that it applies to all types}  Support Proposal 1.2. |
| Spreadtrum | 1a: Implicit associations between Type-A RS and TCI state described by several companies such as ZTE, MediaTeK, Qualcomm can be potential solutions. Regarding the configuration restriction mentioned by Ericsson, we can consider explicit association between Type-A RS and TCI state by RRC signaling. Since Type-A RS for each CC should be configured by RRC anyway, adding an RRC IE into Type-A RS configuration will not cause too much overhead.  1b: We didn’t see any advantage.  2a: similar view as MediaTek. The TCI state pool can be a super set of joint TCI states and UL TCI states, where most of the TCI states can be used for both joint TCI indication and UL TCI indication. Also, we support SRS being resource RS in DL TCI to ensure more TCI states can be shared.  2b: Save RRC overhead.  For proposal 1, we suggest to modify as follow,  **Proposal 1.1**: On Rel.17 unified TCI framework, support the following TCI state pool design for carrier aggregation (CA):   * A single/shared RRC TCI state pool for the set of configured CCs for DL QCL reference and UL TX spatial reference   + Alt-1:     - For QCL Type-A, a CC ID for QCL-Type A source RS is absent in a TCI state. The CC ID for QCL-Type A source RS is determined according to a target CC of the TCI state and configured with source RS ID     - For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeA RS source ID to locate the corresponding QCL Type-A source RS   + Alt-2:     - For QCL Type-A, RRC configures the association between TCI state and QCL-Type A RS in each CC     - For each applied active BWP per CC, UE determines the corresponding QCL Type-A source RS by the RRC configured association * FFS: Whether it is possible that a single TCI state in the pool includes all source RSs from different CCs   {Mod: But supporting two alternatives is not a good direction – we only need one solution}  For proposal 1.2, we don’t think the Note is align with our views and also some other companies’ views, we suggest to remove it.  {Mod: Done, removed} |
| LG2 | On proposal 1.1, we are not supportive on the proposal. gNB should choose N out of M TCI states for activation by MAC-CE, to further indicate 1 out of N by DCI. If we unify TCI state pool configured by RRC across different CCs, it would be difficult for gNB to choose active N TCI states because desired pairs of type-A source and type-D source can be different per CC, meaning that a joint selection would be required at gNB on a cell group basis. In addition, as commented previously, there are pending issues for UL specific parameters related to Pc and TA. If these parameters are included in joint TCI, Alt1 would not work well.  Fundamentally, we are doubtful on the gain of Alt1. It could reduce some RRC payload but the reduced portion of RRC payload would not be so significant considering that this operation is applicable for intra-band CCs only (unless further agreement on the support for inter-band case) and all RS configurations are still needed on a per CC basis which is more dominant part of RRC payload. Required bits for TCI state pool configuration (i.e. pointer to RS ID) would be much smaller than the other parts, e.g. NZP/ZP CSI-RS configuration, CSI measurement and reporting configuration, etc. |
| MediaTek | Support Proposal 1.1. Regarding the concern from Apple/LG/Huawei/Ericsson, we believe the proposal 1.1 doesn't forbid NW to configure TCI pool per CC. Anyhow, whether to group a set of CC will be up to NW decision.  Regarding the DL TCI in Proposal 1.2, according to previous agreement (RAN1#102e), we are wondering whether it is already agreed that it should be the same as joint TCI?  In RAN1#103-e, investigate, for the purpose of down selection, the following alternatives for accommodating the case of separate beam indication for UL and DL   * + Alt1. Utilize the joint TCI to include references for both DL and UL beams   + Alt2. Utilize two separate TCI states, one for DL and one for UL. The TCI state for the DL is the same as agreed in 1a. The TCI state for the UL can be newly introduced.     - Alt 2-1: The UL TCI state is taken from the same pool of TCI states as the DL TCI state     - Alt 2-2: The UL TCI state is taken from another pool of TCI states than the DL TCI state   + Note: The resulting beam indication directly refers to the associated source RS(s)   + FFS (RAN1#103-e): Details on extension to intra- and inter-band CA   + Note: This may be related to issue 5 as well as other reasons for different TCIs such as network flexibility/scheduling   {Mod: Thank you for pointing this out. DL TCI part is now removed and replaced by a note.} |
| vivo | We support the two proposals in principle.  One comment: we would like to clarify the active BWP in the draft proposal. In Rel-16, the update in the CC list is applied across all BWP for all CCs. Would the following be applicable to inactive BWP?   * [For each applied active BWP per CC,] UE uses the corresponding BWP ID + CC ID + QCL TypeA RS source ID to locate the corresponding QCL Type-A source RS |
| Xiaomi | For proposal 1.1, we support it. And we want to clarify the “DL QCL reference” in the main bullet, is it DL QCL reference for Type A or Type A&Type D? Can we add the Type into the main bullet for clarification?  For proposal 1.2, We have a concern on the note, first, we are wondering why SRS for BM can’t be a source RS for DL TCI? Second, If it can’t be a source for DL TCI, gNB can configure other RS as source RS for each TCI state or configure two RSs into a TCI state. So we suggest to remove the note. |
| ZTE | Support Proposal 1.1. Firstly we share the same views with MediaTek that this proposal is NOT to preclude NW to configure TCI state pool per CC. If Ericsson still prefer to configure TCI state pool per CC for flexibility, this function is still open as what we did in Rel-16. But, to be honest, it is difficult for me to imagine why we need to have different TCI state pool in RRC across CC, under the unified TCI state framework. I am not sure whether the following wording can make opponent companies a little bit comfortable, i.e., not preclude NW to configure TCI state pool per CC.  **Proposal 1.1**: On Rel.17 unified TCI framework, support the following TCI state pool design for carrier aggregation (CA):   * A single/shared RRC TCI state pool for the set of configured CCs for DL QCL reference and UL TX spatial reference   + For QCL Type-A, a CC ID for QCL-Type A source RS can be absent in a TCI state.   + When the CC ID for QCL-Type A source RS is absent in the TCI state, the CC ID for QCL-Type A source RS is determined according to a target CC of the TCI state and configured with source RS ID     - For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeA RS source ID to locate the corresponding QCL Type-A source RS   + Note: When RRC TCI state pool is configured per individual CC, reuse Rel-16 cross-CC simultaneous TCI state ID update. * FFS: Whether it is possible that a single TCI state in the pool includes all source RSs from different CCs   Regarding PL and TA issues, we do not identify any issues (like QCL-TypeD, those parameter can be applied across CC). If possible, could any companies clarify the potential issues in their mind?  Support Proposal 1.2. Specifically, in our views, DL/UL TCI shares the same TCI state pool as joint DL/UL TCI. We do not see any technical reason why we can not use a common pool. Striving a unified solution is our first preference.   * For UL TCI state, introducing SRS for BM into UL TCI state is a natural solution for handling this imbalance issue as Xiaomi mentioned. Alternatively, we can further support to have association signalling between TCI state and SRS. When is applied, the SRS is used for determining spatial filter of UL transmission, and herein we can have a condition that the SRS should share the same spatial domain filter as QCL-TypeD RS in the TCI state, if any. * For DL TCI state, it is clear that we can reuse DL TCI shares the same TCI state pool as joint DL/UL TCI (Alt1) |
| MediaTek | Further input for proposal 1:  In our view, if a set of CCs are configured for common TCI activation/update, according to previous agreement at least the followings are supported:   * Support common TCI state ID activation across the set of configured CCs * Support common TCI state ID update across the set of configured CCs * Common TCI state ID implies that a same RS is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs   Now, Proposal 1.1 further specifies “the RS ID” of TypeA source RS in each CC in the CC group should be the same. We don't see why this proposal would mean a tougher restriction. NW still can pair any RS on each CC as TypeA source with the common TypeD source in each TCI state, as the example shown in bellow. |
| Huawei, HiSilicon (2nd batch) | Just to respond to ZTE’s question on potential impacts on uplink power/timing control: One example is, currently the maximum number of maintained PL-RS estimates per serving cell is up to 4. If a single/shared pool for UL TCI is used for multiple CCs, does this imply that the maximum number of maintained PL-RS estimates is multiplied by the number of involved CCs, or it is still up to 4? It would also be necessary to check into uplink timing aspects.  One additional question we missed in the first round is what is the relation between the discussion in Proposal 1.1 (sharing TCI state list for multiple configured/serving CCs) and the discussions in Issue #2 (TCI associated with non-serving cells). Is it correct understanding that in Proposal 1.1, the TCI state list shared among configured/serving CCs may also point to non-serving cells as discussed in Issue #2?  {Mod: Just as other sub-issues in issue 1, this is for intra-cell usage.} |
| InterDigital | Proposal 1.1: For other QCL Types except QCL Type-D, TCI state indication should be based on source RSs in its own cell. For a single/shared RRC TCI state pool, the operation may be possible, but reduces possible number of beams as multiple cells should share TCI states. Given that, we propose to support “a separate RRC TCI state pool for configured CCs” as well as “a single/shared RRC TCI state pool”.  Proposal 1.2: We are fine with the proposal. |
| Samsung2 | Support proposal 1.1. As mentioned by MediaTek and ZTE, Opt-2 is a subset of Opt-1, when “the set of configured CCs” includes one CC only.  For potential uplink power/timing control aspects. For timing aspects, it is not clear why CCs on the same beam would experience different time delays. For power control aspects:   * We are still discussing how the PL-RS is to be included in or associated with the TCI state, multi-carrier operation should be one of the considerations there. * The network has the flexibility to configure the set of CCs with a common TCI state pool. Power control aspects can be one of the consideration for making this configuration.   Proposal 1.2 is OK. But we would like to remove the note at the end. It is pre-mature to conclude that even if the source RS for DL and UL TCI states are not identical that a separate UL TCI state pool is unavoidable. |
| Lenovo/MoM2 | Proposal 1.1: support. Only sharing the same TCI state pool across CC allows reusing the mechanism of simultaenousTCI-Update and simultaneousSpatialRelation-Update. The proposed method for indicating CQL-Type A per CC based on the targeted CC works.  Proposal 1.2: support. We support Alt2 for both UL and DL. |
| Qualcomm | Support Proposal 1.1  Support Proposal 1.2 but without the last note. Because it is not an issue to our understanding. In case of shared pool, each configured TCI can be indicated as DL or UL TCI with corresponding applicable source RS types. The extra RRC overhead to indicate TCI type per TCI is not an issue |
| Moderator | Updated proposal 1.1 and 1.2. Based on the discussion, I still see no technical issue with proposal 1.1 while still seeing the same drawback of Alt1 in proposal 1.2. |
| OPPO3 | Do not support Proposal 1.1: Apparently Opt-1 has much more spec impact than Opt-2 and Opt-1 also impose restriction on system implementation flexibility and scheduling flexibility. So we do not support to agree Opt-1.  Proposal 1.2: Since we think by previous agreements, DL TCI states shares the same pool as joint DL/UL TCI, why do not we just agree whether UL TCI states share the same pool with DL TCI states or not.  {Mod: I don’t think this changes anything content-wise per previous agreements So I’ll stick with the current wording based on joint TCI.}  **Proposal 1.2**: On Rel.17 unified TCI framework, in case of separate DL/UL TCI, decide between the following two alternatives for UL TCI state pool design upon the conclusion of source RS type support for DL QCL reference and UL TX spatial reference:   * Alt1. UL TCI shares the same TCI state pool as ~~joint DL/UL TCI~~ DL TCI states * Alt2. UL TCI uses a separate TCI state pool from ~~joint DL/UL TCI~~ DL TCI states   Note: By previous agreements, DL TCI shares the same TCI state pool as joint DL/UL TCI. |
| Intel | **Proposal 1.1:** It would be good to clarify the channels to which the QCL Type A case is applicable i.e., PDSCH, PDCCH. We still haven’t resolved the FFS from last meeting which discusses if the common beam update across multiple CCs is applicable for a single or sub-set of channels. Pending that discussion, we should clarify where this is applicable.  Proposal 1.2: Ok with current wording based on joint DL/UL TCI states. |
| Moderator | **Proponents of proposal 1.1:** please address Intel’s question and suggest text changes if necessary. |
| Sony2 | For **proposal 1.1**, support in principle.  For CC ID determination of QCL-Type A source RS, we just fail to understand the meaning of highlight part below. If possible, hope it could be clarified.  “The CC ID for QCL-Type A source RS is determined according to a target CC of the TCI state and configured with source RS ID”  For **proposal 1.2**, support in principle.  But from the captured agreement in MTK’s response (copied below FYI), we see “the TCI state for DL is same as agreed in 1a” is an alternative under investigation. Perhaps, it’s fully settled yet. But if I got it wrong, please feel free to let me know.  In RAN1#103-e, investigate, for the purpose of down selection, the following alternatives for accommodating the case of separate beam indication for UL and DL   * + Alt1. Utilize the joint TCI to include references for both DL and UL beams   + Alt2. Utilize two separate TCI states, one for DL and one for UL. The TCI state for the DL is the same as agreed in 1a. The TCI state for the UL can be newly introduced. |
| Docomo | Proposal 1.1: Support in principle. The first bullet covers all QCL types, however, the sub bullets only covers QCL type A. The same proposal should be applied to QCL type D, hence we suggest to add QCL type D as below (the text of QCL-A is copied).  **Proposal 1.1**: On Rel.17 unified TCI framework, support the following TCI state pool design for carrier aggregation (CA):   * A single/shared RRC TCI state pool for the set of configured CCs for DL QCL reference (of all applicable types) and UL TX spatial reference   + For QCL Type-A, a CC ID for QCL-Type A source RS can be absent in a TCI state.   + When the CC ID for QCL-Type A source RS is absent in the TCI state, the CC ID for QCL-Type A source RS is determined according to a target CC of the TCI state and configured with source RS ID     - For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeA RS source ID to locate the corresponding QCL Type-A source RS   + For QCL Type-D, a CC ID for QCL-Type D source RS can be absent in a TCI state.   + When the CC ID for QCL-Type D source RS is absent in the TCI state, the CC ID for QCL-Type D source RS is determined according to a target CC of the TCI state and configured with source RS ID     - For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeD RS source ID to locate the corresponding QCL Type-D source RS   + Note: When RRC TCI state pool is configured per individual CC, reuse Rel-16 cross-CC simultaneous TCI state ID update * FFS: Whether it is possible that a single TCI state in the pool includes all source RSs from different CCs   Proposal 1.2: Support |
| MediaTek | Re Intel, TRS for TypeA + CSI-RS for BM for TypeD can work.  Re DoCoMo, we are not sure why we need to clarify how to determine TypeD source in this proposal since how to determine Type D RS was already agreed in RAN1#103e. However, we still can clarify it again in this proposal as follows:   * A single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs.   Previous agreements:   * The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs   Regarding the note (when RRC TCI state pool is configured per individual CC, reuse Rel-16 cross-CC simultaneous TCI state ID update), we think whether to reuse Rel-16 cross-CC simultaneous TCI state ID update should be NW implementation. Without Rel-16 cross-CC simultaneous TCI, we don't see why per CC update is not workable in this case.  Re Sony, yes, to our understading, the alternatives were down-selected in the previous meeting according to the following agreement.  **Agreement RAN1#103e**  On Rel-17 unified TCI framework, to accommodate the case of separate beam indication for UL and DL:   * Utilize two separate TCI states, one for DL and one for UL.   + FFS: Contents of separate UL TCI state   + Note: For FR1, UE does not expect UL TCI to provide a reference for determining common UL TX spatial filter(s), if UL TCI is supported for FR1 * For the separate DL TCI:   + The source reference signal(s) in M TCIs provide QCL information at least for UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC * For the separate UL TCI:   + The source reference signal(s) in N TCIs provide a reference for determining common UL TX spatial filter(s) at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   + Optionally, this UL TX spatial filter can also apply to all SRS resources in resource set(s) configured for antenna switching/codebook-based/non-codebook-based UL transmissions * FFS: Whether the UL TCI state is taken from a common/same or separate TCI state pool from DL TCI state   + Note that TCI state pool for joint DL and UL beam indication is still FFS * FFS: Whether Rel.17 supports TCI configured for single channel (e.g. PDSCH only, single CORESET) * Note: This does not preclude the type of UE supporting only 1 beam tracking loop, i.e. UE reports value of 1 in UE FG 2-62. |

### Issue 2 (L1/L2-centric inter-cell mobility)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.5 | Source RS type(s) applicable for L1/L2-centric inter-cell mobility  Note: currently there is no agreement on supported source RS type(s) for L1/L2-centric inter-cell mobility | SSB:   * **Yes**: * **No**:   CSI-RS for mobility:   * **Yes**: Lenovo/MoM, Huawei/HiSi, LGE, Sony. CATT, ZTE * **No**: Samsung, Qualcomm, Intel, MTK, Apple, OPPO, Nokia/NSB, Futurewei   CSI-RS for tracking:   * **Yes**: Samsung, ZTE, Futurewei, Huawei/HiSi * **No**: Qualcomm, Intel, MTK, OPPO, Nokia/NSB   CSI-RS for BM:   * **Yes**: Futurewei * **No**: |

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| Previous agreement (RAN1#103-e)   * The following enhancement scope is assumed:   + Facilitating measurement and reporting of non-serving RSs via incorporating non-serving cell info with some TCI(s), along with the necessary measurement and reporting scheme(s)     - FFS: Detailed/exact method(s)     - FFS: Whether this also implies the support of beam indication (TCI state update along with the necessary TCI state activation) for TCI(s) associated with non-serving cell RS(s)     - FFS: Metric for the measurement and reporting, e.g. L1-RSRP or L3-RSRP or time- or spatial-domain-filtered L1-RSRP     - FFS: Beam-level event-driven mechanism, using serving cell RS and/or non-serving cell RS   + … |

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| Action: Interested companies are encouraged to share their views on the following questions:   1. Supporting beam indication (TCI state update along with the necessary TCI state activation) for TCI(s) associated with non-serving cell RS(s) – yes or no? 2. If #1 is affirmative, what type(s) of source RS shall be supported for providing:    1. QCL information for UE-dedicated PDSCH/PDCCH reception?    2. UL TX spatial filter information for PUSCH/PUCCH?   Goal: Finalize the proposal to be ready for endorsement |

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| **Proposal 2.1**: On Rel.17 enhancements for L1/L2-centric inter-cell mobility:   * Support the TCI state update (beam indication mechanism) using TCI(s) associated with non-serving cell RS(s) based on the TCI state update mechanism agreed for the Rel.17 unified TCI framework:   + FFS (by RAN1#104bis-e): Select the applicable channels/signals, e.g. UE-dedicated PDSCH, UE-dedicated PDCCH (CORESETs), UE-dedicated PUSCH, UE-dedicated PUCCH, some reference signals   + FFS how to update beams for subset of channels with Rel.17 unified TCI framework   + FFS: whether/how a TCI associated with non-serving cell RS(s) is indicated to CORESET#0 * FFS: Whether to support at least the source RS types already agreed for intra-cell mobility for the purpose of referencing to non-serving cell(s). Note: This implies that the following source RS(s) are supported   + CSI-RS for BM configured for non-serving cell(s) for DL QCL and UL TX spatial references   + CSI-RS for tracking (TRS) configured for non-serving cell(s) for DL QCL and UL TX spatial references   + SSB configured for non-serving cell(s) for UL TX spatial references   + SRS for BM configured for non-serving cell(s) for UL TX spatial references   + FFS: whether to support CSI-RS for mobility   + FFS: whether to support other source RS(s) potentially agreed later for intra-cell mobility   + FFS: whether to support CSI-RS for BM and tracking configured for non-serving cell(s) and without non-serving cell SSB as QCL-TypeD source * The L1/L2-centric inter-cell mobility only supports intra-DU operation but does not support inter-DU operation. * The L1/L2-centric inter-cell mobility does not apply to inter-band CA and inter-frequency scenarios. * It is assumed that C-RNTI can be updated when UE receives DL channel RS associated to non-serving cell RS as QCL source for DL reception and UL transmission, at least for UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH * Send an LS to ask RAN2 to provide answers for the followings FFS assumptions for L1/L2-centric inter-cell mobility:   + Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated for DL reception and UL transmission, at least for UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH   + Whether some RRC parameters need to be updated without additional RRC signaling, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source   + Whether UE needs/can change serving cell during L1/L2-centric inter-cell mobility. |

Table 4 Inputs: issue 2

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| **Company** | **Input** |
| Moderator | Please provide answers to the questions |
| Apple | Q1: Yes  Q2a/Q2b: all RSs based on legacy QCL rule can be allowed |
| CATT | Q1: Yes  Q2: all RS allowed in legacy QCL provision (unless there is good reason for their exclusion) |
| APT | Q1: yes  Q2: all RS allowed in legacy QCL provision. The RSs should have QCL source configured, except for SSB. |
| ZTE | Q1: Not sure. Currently we only agree that SSB can be used for non-serving cell measurement. But, since according to legacy QCL rule, SSB can NOT be applied to PDCCH/PDSCH reception, we need to consider whether CSI-RS for tracking/CSI as QCL Type-A can be from non-serving cell or serving cell firstly.   |  | | --- | | For the DM-RS of PDCCH, the UE shall expect that a TCI-State indicates one of the following quasi co-location type(s):  - 'QCL-TypeA' with a CSI-RS resource in a NZP-CSI-RS-ResourceSet configured with higher layer parameter trs-Info and, when applicable, 'QCL-TypeD' with the same CSI-RS resource, or  - 'QCL-TypeA' with a CSI-RS resource in a NZP-CSI-RS-ResourceSet configured with higher layer parameter trs-Info and, when applicable, 'QCL-TypeD' with a CSI-RS resource in an NZP-CSI-RS-ResourceSet configured with higher layer parameter repetition, or  - 'QCL-TypeA' with a CSI-RS resource in a NZP-CSI-RS-ResourceSet configured without higher layer parameter trs-Info and without higher layer parameter repetition and, when applicable, 'QCL-TypeD' with the same CSI-RS resource. |   {Mod: Good point. As of now, we have no agreement on source RS(s) for inter-cell and this is perhaps a source of ambiguity. Proposal 2.1 attempts to partially address this. Please check if the FFSs on source RS(s) and sourcing mechanism resolve your concern.}  Q2: CSI-RS for BM without QCL assumption, CSI-RS for CSI and CSI-RS for tracking can be supported. |
| LG | Q1: Yes  Q2: Type of source RSs can be same as Rel-15/16 for PDSCH/PDCCH/PUCCH/PUSCH. Only change would be to allow NSC SSB or mobility CSI-RS as top QCL source. |
| MediaTek | Q1: Yes  Q2a/Q2b: all RSs based on legacy QCL rule can be allowed. Necessary extension can be considered, especially for TypeA/C QCL. |
| TCL | Q1: Yes  Q2: All RSs are allowed, but the priority of these RSs needs further discussion. |
| Xiaomi | Q1: Yes  Q2: when CSI-RS configured as a source RS, is it necessary to let UE know the CSI-RS refer to serving cell or non-serving cell? |
| Docomo | Q1: Yes  Q2a: all RSs based on legacy QCL rule can be allowed  Q2b: it would be ok as long as QCLtype D is supported, to determine UL spatial domain filter. |
| Ericsson | Q1: Yes  Q2: all RS allowed for the legacy QCL provision. For DL QCL, these rules have been confirmed for unified TCI as well.  To progress the discussion, perhaps we can start from this proposal:  Support the following TCI state update (beam indication) mechanism based on the Rel.17 unified TCI framework:   * Support the use of non-serving SSB at least as an indirect QCL assumption for reception of PDCCH /PDSCH * Support the use of SSB (s) of non-serving cell(s) for determining common UL TX spatial filter for transmission of PUCCH /PUSCH * Note: an SSB is an indirect QCL source of PDCCH /PDSCH if the SSB is the QCL source of a CSI -RS that is the QCL source of the PDCCH /PDSCH DMRS   {Mod: Thank you. This is a good start + incorporating inputs from other companies} |
| vivo | Q1: Positive, but restrictions may be put on cases where such beam indication would need more discussion. For example whether such beam indication for all channels;  Q2: We don’t see necessity to change compared to already agreed ones for the serving cell RS. |
| Sony | Q1: Yes  Q2a/Q2b: CSI-RS for mobility along with SSB can be used as source RS of QCL/spatial relation for DL reception and UL transmission |
| Nokia | Q1: Yes  Q2: We do not think RAN1 agreed to support PDSCH/PUSCH or PUCCH from/toward non-serving cell yet. And we consider SSB as the only QCL source for non-serving cell.  {Mod: From the above input, my understanding is that while Nokia is positive on supporting beam indication but the applicability to which channels needs further discussion.} |
| Samsung | Q1: Yes, based on the Rel-17 beam indication scheme for serving cell.  Q2: In the context of the unified TCI state framework, the baseline should be that the same source RS types agree for serving should be supported for non-serving cell. There is no clear motivation to add or remove source RS types. This applies to QCL Type-D for DL channels as well as UL TX spatial filter for UL channels. It is too early to say that the SSB has to be an indirect source, as it is still open whether the SSB can be a source RS for the serving cell case. |
| OPPO | Q1: it is too early to discuss that now. We still have so many open issue on FFS on RRC and use case assumptions. The agreement made in RAN1#103e is copied here. Before we can align and conclude on those FFS point, we do not suggest to discuss the detailed design of beam indication of non-serving cell SSB. The conclusion on RRC/use case have critical impact on the design. Different conclusion would result in different designs.  Q2: we do not support to discuss Q1 before we can verify those FFS point.   |  | | --- | | **Agreement**  On Rel-17 enhancements to enable L1/L2-centric inter-cell mobility:   * The following use cases are assumed:   + Network architecture:     - NSA, i.e. LTE PCell and NR-PSCell     - SA   + Intra-band CA     - FFS: If inter-band CA is also included   + Intra- RAT (excluding inter-RAT)   + Intra-frequency scenario:     - The SSBs of non-serving cells have the same center frequency and SCS as the SSBs of the serving cell     - An SSB of a non-serving cell is associated with a PCI different from the PCI of the serving cell     - FFS: Support for inter-frequency scenario   + FFS: Whether to support intra-DU only operation, or whether inter-DU is also allowed * The following enhancement scope is assumed:   + Facilitating measurement and reporting of non-serving RSs via incorporating non-serving cell info with some TCI(s), along with the necessary measurement and reporting scheme(s)     - FFS: Detailed/exact method(s)     - FFS: Whether this also implies the support of beam indication (TCI state update along with the necessary TCI state activation) for TCI(s) associated with non-serving cell RS(s)     - FFS: Metric for the measurement and reporting, e.g. L1-RSRP or L3-RSRP or time- or spatial-domain-filtered L1-RSRP     - FFS: Beam-level event-driven mechanism, using serving cell RS and/or non-serving cell RS   + Facilitate serving cell to provide configurations for non-serving cell SSBs via RRC     - FFS: details for the configurations, e.g. time/frequency location, transmission power, etc.     - FFS: other information needed for inter-cell mobility   + Note: In RAN1's understanding, non-serving cell SSB and non-serving cell RS can be part of the serving cell configuration * FFS: The following enhancement scope is assumed by RAN1:   + Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated     - A non-serving cell RS is an RS that is or has an SSB of a non-serving cell as direct or indirect QCL source     - This implies no C-RNTI update when UE receives DL channel RS associated to non-serving cell RS as QCL source.     - FFS whether TCI associated with non-serving cell can be indicated to or are applicable for all channels.   + Whether some RRC parameters need to be updated without additional RRC signaling, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source   + Whether UE needs/can change serving cell during L1/L2-centric inter-cell mobility.   + The above assumption to be verified by RAN2 |   {Mod: I fully sympathize (and tend to agree) with OPPO’s concern especially related to the RRC reconfiguration. I can see how this might impact what can be done for PDSCH/PDCCH reception and/or PUSCH/PUCCH transmission. But we have tried this in round 1 (send an LS to RAN2 on the list we need RAN2 to answer) and failed. I don’t mind trying this again if companies who raise concern on this can confirm they are ok to proceed this way.  Otherwise, given companies’ views, proposal 2.1 could be a step we take before we resolve the yellow FFS?} |
| Qualcomm | For Q1:   * To clarify, we support beam indication for TCI(s) with source RS as non-serving cell RS(s), which is defined below as in previous agreement   + - A non-serving cell RS is an RS that is or has an SSB of a non-serving cell as direct or indirect QCL source   For Q2-a: SSB and CSI-RS for BM  For Q2-b: SSB and CSI-RS for BM |
| InterDigital | Action: Interested companies are encouraged to share their views on the following questions:  1. Supporting beam indication (TCI state update along with the necessary TCI state activation) for TCI(s) asso-ciated with non-serving cell RS(s) – yes or no?  2. If #1 is affirmative, what type(s) of source RS shall be supported for providing:  a. QCL information for UE-dedicated PDSCH/PDCCH reception?  b. UL TX spatial filter information for PUSCH/PUCCH?  1. Yes  2. a. TRS of serving cell based on SRS of non-serving cell  2. b. If it is based on DL RS, same as 2.a. If it is based on UL RS, no enhancement is needed. |
| Lenovo/MoM | Q1: Yes  Q2a: SSB and CSI-RS for mobility in addition to R16 allowed RS types.  Q2b: SSB and CSI-RS for mobility in addition to R16 allowed RS types. |
| Intel | Q1: Yes  Q2: We are ok with Ericsson’s baseline. |
| Intel | Q1: Yes  Q2: We are ok with Ericsson’s baseline. |
| Futurewei | Q1: Yes.  Q2-a: CSI-RS for tracking and CSI-RS for BM.  Q2-b: CSI-RS for tracking and CSI-RS for BM. |
| Moderator | From companies’ inputs, there is a strong majority on supporting beam indication for NSCs except for 2 companies (due to some valid concerns related to unresolved FFS from the previous meeting and zero agreement on source RS for inter-cell).  To date there is no agreement on applicable source RS types for inter-cell. This needs to be resolved before we can agree on sourcing mechanism (even indirect sourcing cannot be done before we can agree on one type of source RS). Likewise, the agreement on QCL rule in issue 1 only applies to intra-cell. There is no agreement on QCL rule for inter-cell. Therefore, these issues needs to be resolved.  Proposal 2.1 is an attempt to progress on the above issues while still agreeing on beam indication support (given the majority view) – without discounting the valid concerns raised by some companies. |
| OPPO2 | To the FL, I am not sure that the proper way to proceed. We still have many FFS on use cases and assumptions of RRC reconfiguration answered, but we now skip them and begin to discuss design. To proceed, in our view, we shall first conclude on the use cases and assumption of RRC reconfiguration, which are agreed in RAN1#103e. So we propose to add two bullet to clarify the use cases which is FFSed, send LS to RAN2 to ask RAN2 to clarify those questions on RRC reconfiguration/C-RNTI update/serving cell change.  Here is suggested change to Proposal 2.1  **Proposal 2.1**: On Rel.17 multi beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility:   * Support the TCI state update (beam indication mechanism) for TCI(s) associated with non-serving cell RS(s) based on the Rel.17 unified TCI framework:   + FFS (by RAN1#104bis-e): Select the applicable channels/signals, e.g. UE-dedicated PDSCH, UE-dedicated PDCCH (CORESETs), UE-dedicated PUSCH, UE-dedicated PUCCH, some reference signals * Support at least the source RS types already agreed for intra-cell mobility for the purpose of referencing to non-serving cell(s). Note: This implies that the following source RS(s) are supported   + CSI-RS for BM associated with non-serving cell(s) for DL QCL and UL TX spatial references   + CSI-RS for tracking (TRS) associated with non-serving cell(s) for DL QCL and UL TX spatial references   + SSB associated with non-serving cell(s) for UL TX spatial references   + SRS for BM associated with non-serving cell(s) for UL TX spatial references   + FFS: whether to support CSI-RS for mobility   + FFS: whether to support other source RS(s) potentially agreed later for intra-cell mobility * FFS (no later than RAN1#105-e): Select at least one from the following candidates of sourcing mechanism (for DL QCL reference and UL TX spatial reference):   + Direct referencing of source RS(s)   + Indirect referencing of source RS(s)     - Example: an SSB is an indirect QCL source of PDCCH /PDSCH if the SSB is the QCL source of a TRS that is the QCL source of the PDCCH /PDSCH DMRS   + Note: The applicable mechanism(s) can be different for DL QCL and UL TX spatial references * The L1/L2-centric inter-cell mobility only supports intra-DU operation but not support inter-DU operation. * The L1/L2-centri inter-cell mobility does not apply to inter-band CA and inter-frequency scenarios. * Send a LS to ask RAN2 to provide answers for the followings FFS assumptions for L1/L2-centric inter-cell mobility: * Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated * Whether C-RNTI is updated when UE receives DL channel RS associated to non-serving cell RS as QCL source. * FFS whether TCI associated with non-serving cell can be indicated to or are applicable for all channels. * Whether some RRC parameters need to be updated without additional RRC signal-ing, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source * Whether UE needs/can change serving cell during L1/L2-centric inter-cell mobility.   {Mod: I appreciate OPPO’s concern and acknowledge the points. As said above the FL proposal on supporting beam indication for L12-XCM is based on the super-majority view. Your proposal above is constructive. I added the above with some modification – please check (one bullet is merged to 2 others, sounds redundant), also one bullet is moved up per Samsung’s suggestion} |
| Huawei, HiSilicon | Proposal 2.1:  The main bullet says ‘beam measurement/reporting’, but we think the proposal being discussed is more about beam indication.  The first bullet (and previous agreement) is not well formulated in our view, as beam indication is not performed ‘for’ TCI, but instead ‘using’ TCI.  {Mod: thanks, done}  In the second bullet, we are not sure whether SRS for BM associated with non-serving cell can really be considered here (there is no SRS for BM associated with non-serving cell in our understanding).  Regarding the third bullet, we are wondering why not try to agree on what has been agreed for intra-cell case (i.e., indirect referencing) together, given that similar approach has been adopted for the second bullet.  {Mod: 3rd bullet is removed} |
| Docomo | Support proposal 2.1. We would like to clarify that the last FFS is only applicable for non-serving cell.   * FFS (no later than RAN1#105-e): Select at least one from the following candidates of sourcing mechanism (for DL QCL reference and UL TX spatial reference) of QCL source on non-serving cell:   + Direct referencing of source RS(s)   + Indirect referencing of source RS(s)     - Example: an SSB is an indirect QCL source of PDCCH /PDSCH if the SSB is the QCL source of a TRS that is the QCL source of the PDCCH /PDSCH DMRS   + Note: The applicable mechanism(s) can be different for DL QCL and UL TX spatial references   {Mod: 3rd bullet is now removed per Samsung’s concern} |
| Spreadtrum | We support beam indication for TCI(s) associated with non-serving cell RS(s). Besides, we have a general question on the discussion scope between inter-cell mobility and inter-cell M-TRP, since QCL indication and RS types are being discussed in AI 8.1.2.2 already.  {Mod: As discussed before, 8.1.2.2 assumes Rel.15/16 framework while issue 2 of 8.1.1 is based on Rel.17 unified TCI framework. Also, L12-XCM is “DPS-like” unlike XC-mTRP} |
| LG2 | Fine with FL’s proposal. Not support the addition by OPPO (especially the LS part). Please note that RAN2 has no TU for this.  {Mod: From FL perspective, despite my reservation, OPPO’s point is technically correct (unfortunately). Without the answers from RAN2, it is unclear if we can even do DL RX/UL TX from/to NSC(s).We will discuss TU in March RAN.} |
| vivo | We are supportive of the FL proposal. One comment is related to the case when only a subset of channels are applicable for the following operation, how would Rel-17 framework be applied?  Support the TCI state update (beam indication mechanism) for TCI(s) associated with non-serving cell RS(s) based on the Rel.17 unified TCI framework:   * Support the TCI state update (beam indication mechanism) for TCI(s) associated with non-serving cell RS(s) based on the Rel.17 unified TCI framework:   + FFS (by RAN1#104bis-e): Select the applicable channels/signals, e.g. UE-dedicated PDSCH, UE-dedicated PDCCH (CORESETs), UE-dedicated PUSCH, UE-dedicated PUCCH, some reference signals   + FFS how to update beams for subset of channels with Rel.17 unified TCI framework   {Mod: Done in 5Vs ☺} |
| Xiaomi | Support the FL proposal |
| ZTE | We can NOT support FL proposal that is not aligned with normal RAN1 discussion procedure. Firstly, the applicable scenario and usage are both unclear. As OPPO mentioned, we shall first conclude on the use cases and assumption of RRC reconfiguration, which are agreed in RAN1#103e. Therefore, sending LS to RAN2 for further clarifiying questions on RRC reconfiguration/C-RNTI update/serving cell change is very necessary.  {Mod: I tend to agree that some answers from RAN2 are needed. As a compromise, I added the bullets proposed by OPPO and }  Then, regarding first bullet, before agreeing “Support the TCI state update (beam indication mechanism) for TCI(s) associated with non-serving cell RS(s) based on the Rel.17 unified TCI framework”, we need to agree the source RS and target channel firstly. We can NOT live with a very general description above.  Finally, regarding second bullet, we think that we need to fix the hole that we made for different types of RS that are applied to DL and UL channel/RS.   * SSB can be used as QCL source for non-serving cell for PDCCH/PDSCH/PUSCH/PUCCH; * Also, SRS can be used as QCL source for non-serving cell for PDCCH/PDSCH/PUSCH/PUCCH.   Consequently, the following modification is suggested.  {Mod: Re the applicable channels, as pointed out by at least by OPPO, Nokia, and Samsung, RAN2 needs to confirm if DL RX.UL TX from/to NSC(s) is feasible conditioned on RRC reconfiguration, C-RNTI change, etc.}  **Proposal 2.1**: On Rel.17 enhancements for L1/L2-centric inter-cell mobility:   * Support the following source RS types for intra-cell mobility for the purpose of referencing to non-serving cell(s) at least for PDCCH, PDSCH, PUCCH and PUSCH.   + CSI-RS for BM associated with non-serving cell(s) for DL QCL and UL TX spatial references   + CSI-RS for tracking (TRS) associated with non-serving cell(s) for DL QCL and UL TX spatial references   + SSB associated with non-serving cell(s) for UL TX spatial references   + SRS for BM associated with non-serving cell(s) for UL TX spatial references   + FFS: whether to support CSI-RS for mobility   + FFS: whether to support other source RS(s) potentially agreed later for intra-cell mobility * FFS (no later than RAN1#105-e): Select at least one from the following candidates of sourcing mechanism (for DL QCL reference and UL TX spatial reference):   + Direct referencing of source RS(s)   + Indirect referencing of source RS(s)     - Example: an SSB is an indirect QCL source of PDCCH /PDSCH if the SSB is the QCL source of a TRS that is the QCL source of the PDCCH /PDSCH DMRS   + Note: The applicable mechanism(s) can be different for DL QCL and UL TX spatial references * Send a LS to ask RAN2 to provide answers for the followings FFS assumptions for L1/L2-centric inter-cell mobility: * Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated * Whether C-RNTI is updated when UE receives DL channel RS associated to non-serving cell RS as QCL source. * FFS whether TCI associated with non-serving cell can be indicated to or are applicable for all channels.   Whether some RRC parameters need to be updated without additional RRC signal-ing, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source{Mod: Please check the modified proposal. Hope it addresses your concern, at least partially.} |
| Nokia2 | We think that the discussion/style of making agreements needs a bit more structure. In short, we do NOT agree with the current proposal. We are fine with the first bullet saying that we extend the TCI framework. Having the list of applicable channels as FFS is something we agree, in this respect we have a divergence with that ZTE just updated above. We also see problematic “throwing around” some types of reference signals, but letting as FFS the way in which WCL rules are applied. In this respect we agreed with the Note Ericsson had above there a clear QCL rule was stated. This is indeed captured in the FFS as direct/Indirect way of linking RSs, but then we want to agree on this and the corresponding RSs in the same time, what is the benefit of doing the agreements in this way? On sending LS to RAN2 with questions, we support this and perhaps better discussion is needed on the content and how to put the questions to RAN2 so that the clear interpretation for our enhancement is understood by RAN2.  {Mod: Thanks for agreeing to send an LS with the questions} |
| InterDigital | We don’t support the second main bullet and prefer to keep it as FFS.   * FFS: Support at least the source RS types already agreed for intra-cell mobility for the purpose of referencing to non-serving cell(s). Note: This implies that the following source RS(s) are supported |
| Samsung2 | * Regarding the FL’s proposal,   + First, we would like to ask about the rationale of having the first FFS in the first bullet while proposing to agree on the support of beam indication w.r.t. NSC. If the NSC beam indication framework is based on that of serving cell, wouldn’t it be automatically or at least naturally applicable to all channels associated with non-serving cells?   + We also propose to remove the 3rd bullet on sourcing mechanism. Agreeing on or discussing indirect QCL sourcing is not needed. What’s needed to be agreed is the types of source RS applicable to inter-cell (already captured in 2nd bullet, to be finalized next meeting).   {Mod: As you pointed out below (also other companies), DL RX/UL TX from/to NSC(s) may be contingent to RRC reconfiguration and/or C-RNTI change. Logically, if we agree on the channels without having proper resolution on at least these two issues, we may end up with a scheme that doesn’t work. The support for beam indication for L12-XCM is supported by super-majority. I hope we can at least take this first step – which also serves as a basis for the RAN2 LS.  The 3rd bullet is removed.}   * Regarding Oppo’s point on the need to decide on the FFS’s of the earlier agreement on RRC before progressing on the beam indication design, we think that this is a fair point to consider as there could be some inter-dependencies. Just to give one example, we have not yet decided whether to only support intra-DU operation, or inter-DU operation as well. This can have an impact on the beam indication design. * Related to this, another potential problem is the assumption on C-RNTI, e.g. if PDSCH/PDCCH reception from non-serving cell is supported via beam indication, the UE must know the C-RNTI (cell-assigned UE ID) assigned by the non-serving cell.   + Therefore, C-RNTI update seems needed. We propose to add the following bullet “It is assumed that C-RNTI can be updated for or at least known by the UE upon receiving PDSCH/PDCCH from a non-serving cell” and remove the second sub-bullet from OPPO’s last bullet (RAN2 LS)   + Whether RRC reconfiguration is needed can be discussed further, depending on whether/when an LS can be sent to RAN2. We tend to agree that this needs some resolution preferably before any advanced decision is made.   {Mod: Done with some rewording} |
| Lenovo/MoM | We understand where the FL came from with this proposal, but we think proposal 2.1 has really 2 different proposals: the first bullet is on TCI state, and the second and third bullets are on the RS types. These two aspects are related but different, and are best put as two separate proposals. Here is our view on the three bullets of this proposal:  Bullet 1:We support the first bullet on TCI state update.  Bullet 2: We think the second bullet on source RS types needs further study. For example, can SRS for BM associated with NSC be used for UL TX spatial relation?  Bullet 3: We can support this bullet. |
| Qualcomm | For Proposal 2.1, suggest to replace “RS associated with non-serving cell” with “RS configured for non-serving cell” to avoid ambiguity on the meaning of association. Also suggest to first agreed CSI-RS for BM and tracking with non-serving SSB as QCL source. We have concern if they are not QCLed with SSB.   * Support at least the source RS types already agreed for intra-cell mobility for the purpose of referencing to non-serving cell(s). Note: This implies that the following source RS(s) are supported   + CSI-RS for BM ~~associated with non-serving cell(s)~~ configured for non-serving cell(s) and with non-serving cell SSB as direct or indirect QCL-TypeD source for DL QCL and UL TX spatial references   + CSI-RS for tracking (TRS) ~~associated with non-serving cell(s)~~ configured for non-serving cell(s) and with non-serving cell SSB as direct or indirect QCL-TypeD source for DL QCL and UL TX spatial references   + SSB ~~associated with~~ configured for non-serving cell(s) for UL TX spatial references   + SRS for BM ~~associated with~~ configured for non-serving cell(s) for UL TX spatial references   + FFS: whether to support CSI-RS for mobility   + FFS: whether to support other source RS(s) potentially agreed later for intra-cell mobility   + FFS: whether to support CSI-RS for BM and tracking configured for non-serving cell(s) and without non-serving cell SSB as direct or indirect QCL-TypeD source   {Mod: Added but please see Samsung’s concern on 3rd bullet regarding “indirect” – so I added your suggestion without any mention of indirect} |
| Moderator | Proposal 2.1 is revised. The bullet on source RS is now FFS. 3rd bullet is removed. Added bullets on assumptions and sending an LS to RAN2 on pending issues. |
| OPPO3 | The latest proposal 2.1 looks ok to us. One minor change suggestion: CORESET#0 can also be indicated with UE-specific TCI state according to the design in rel15/rel16. For L1/L2 inter mobility, we shall study whether a TCI state with non-serving cell RS can be indicated to the CORESET#0.  **Proposal 2.1**: On Rel.17 enhancements for L1/L2-centric inter-cell mobility:   * Support the TCI state update (beam indication mechanism) using TCI(s) associated with non-serving cell RS(s) based on the Rel.17 unified TCI framework:   + FFS (by RAN1#104bis-e): Select the applicable channels/signals, e.g. UE-dedicated PDSCH, UE-dedicated PDCCH (CORESETs), UE-dedicated PUSCH, UE-dedicated PUCCH, some reference signals   + FFS: whether/how a TCI associated with non-serving cell RS(s) is indicated to CORESET#0.   + FFS how to update beams for subset of channels with Rel.17 unified TCI framework * FFS: Whether to support at least the source RS types already agreed for intra-cell mobility for the purpose of referencing to non-serving cell(s). Note: This implies that the following source RS(s) are supported   … |
| Intel | Since the entire second bullet is FFS, we now have additional FFS points for the RSs under this FFS. This formulation seems strange. On SRS for BM from non-serving cell, it is not clear to us how this is configured/used.  For the third last bullet on C-RNTI change, it is preferable to check with RAN2 before making a RAN1 agreement. It should be part of the LS being sent to RAN2 i.e., sub-bullet under the last bullet.  {Mod: Some companies (see above comments) have correctly pointed out that without C-RNTI change (or at least additional knowledge on NSC(s)), DL reception and UL transmission associated with NSC(s) may not be possible. I tend to agree and this could be one important component ro make sure L12-XCM works. We will inform RAN2 that this agreement is made and request their feedback.}  Regarding the FFS on how to update beams for a subset of channels, we think that is a general discussion for intra-cell as well for Rel-17 unified TCI framework which has been captured in previous FFS points. Therefore, it should be discussed as part of the unified TCI framework discussion and not specifically for L1/L2-inter cell mobility. The main bullet already says Rel-17 Unified TCI framework is supported which should imply that the issue of application of indicated beams to a sub-set of channels/RS(s) is also applicable.  {Mod: Issue 1 is intended for intra-cell (regular beam management). As correctly pointed out by several companies (see above), what’s applicable for intra-cell doesn’t necessarily apply to inter-cell without any additional agreement. What pertains to inter-cell will be discussed in issue 2.  Re “The main bullet already says Rel-17 Unified TCI framework”, this refers to the beam indication used for the Rel.17 unified TCI framework. I added some clarification} |
| Moderator | Revised proposal 2.1 per OPPO’s additional suggestion and Intel’s. |
| Sony2 | For **proposal 2.1**, support it in principle.  We also share the same feeling with a few others that current proposal doesn’t state which channel/signal the source RS could be applied to, e.g. PDSCH/CSI-RS/PUSCH/SRS. Should we wait for RAN2’s LS back and then continue or could we keep the applicable channel/signal under study? Thanks. |
| Docomo | We have concern for the following text. Precluding inter band CA will limit the use case of this feature. We don’t understand why we need to preclude the inter band CA in inter cell mobility. Even in issue 1, inter band CA is FFS. This bullet should be removed.   * The L1/L2-centric inter-cell mobility does not apply to inter-band CA and inter-frequency scenarios. |
| MediaTek | Support but with one point. Since Rel-17 unified TCI framework already support DCI-based beam indication, dynamic swishing between different cells becomes possible. However, now RAN1 cannot guarantee such cell switching will not involve any configuration change. We have concern on the UE implementation issue to support dynamic cell switching. Therefore, we would like to add one item of further study:   * FFS : If UE receives an activation command activates more than one TCI states, whether to support the activated TCI states associated with QCL sources from different cells |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 3.1 | Beam application time definition:  Alt1: Measured from DCI reception  Alt2: Measured from ACK transmission | **Alt1 (DCI) (7):** Spreadtrum, Xiaomi, Ericsson, CATT, MTK, NEC, Samsung  **Alt2 (ACK) (17):** IDC, Lenovo/MoM, Fujitsu, Nokia/NSB, CMCC, Apple, Huawei/HiSi, ZTE, vivo, Intel, Sony, Qualcomm, NTT Docomo, APT  **Alt1 and Alt 2:** OPPO (Since Alt1 considers the requirement of UE and Alt2 considers the requirement of gNB side), LG (Alt1 for DL assignment/PDSCH of the DCI, Alt2 else) | |

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| Previous agreement (RAN1#103-e):  On Rel.17 DCI-based beam indication:   * Regarding application time of the beam indication: if beam indication is received, down-select from the following:   + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication   + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication   + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y * FFS: When to apply the minimum indication delay (e.g., when the newly indicated beam is different with the previously indicated beam) |

From round-2B discussion, the following proposal for refining Alt1 was made (Qualcomm, Spreadtrum: reworded from UE perspective):

* Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication
  + The UE may assume that the (gNB-)configured application time is after the acknowledgement.

Some companies also commented that the decision on beam application time (BAT) should be dependent on the decision whether an additional DCI format for beam indication is supported or not.

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| **Proposal 3.1**: On Rel.17 DCI-based beam indication, regarding application time of the beam indication: if beam indication is received and the newly indicated beam in the beam indication is different from the previously indicated beam, down-select (no later than RAN1#105-e) one from the following. No other alternatives will be considered:   * Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication * Alt2A: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication * Alt 2B: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication, except that the (new) TCI state update can be applied to the PDSCH (scheduled by the beam indication DCI) and corresponding ACK transmission (provided that the time offset between the DCI and the scheduled PDSCH exceed the threshold, analogous to Rel.15/16) * Alt2C: Support both Alt1 and Alt2A, and introduce a UE capability that indicates the support of Alt1 or Alt2A * Alt3: the first slot that is at least X1 ms or Y1 symbols after the DCI with beam indication and X2 ms or Y2 symbols after the acknowledgment of the beam indication * FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y |

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| Action: Interested companies are encouraged to provide their inputs on the proposal.  Goal: Finalize the proposal for endorsement |

Table 6 Inputs: issue 3

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| **Company** | **Input** |
| Moderator | Proposal 3.1 is essentially the previous agreement with Alt1B added and a deadline for decision. The new part is highlighted in blue |
| Apple | For both Alt1B and Alt2, we suggest to change “acknowledgement” into “last symbol of the acknowledgement”. |
| APT | We wonder if Alt1A is still needed since it does not address the concern of mis-alignment issue between gNB and UE on the beam to be used. We suggest to remove Alt1A to avoid similar argument in next meetings. |
| ZTE | Alt2 is supported.  In our views, the Alt 1B is similar to Alt 2 in general, but we do not want to have a complicate timeline for gNB implementation. |
| LG | First of all, as commented/questioned multiple times, there is no strong need to define a unified BAT for different DL/UL channels because UE cannot receive or transmit them simultaneously anyway. More importantly, the TCI in a DCI should be able to apply to the scheduled PDSCH by the DCI as Rel-15/16 (**same behavior as when TCI is present in DCI**). So, we have strong concern on Alt1B and Alt2 because it precludes the use of indicated TCI for the scheduled PDSCH. If we’d like to go with Alt2, the scheduled PDSCH should be an exception as in Rel-15/16.  {Mod: Added as 2B – please check} |
| MediaTek | For Alt1B, we don’t see the difference between Alt1B and Alt2, where the BAT is still after the acknowledgement. It is not a compromised solution between Alt1A and Alt2, right? We don't think it is helpful to add this alternative at this moment. |
| TCL | In our opinion, Alt 1A is still needed, and similar to ZTE, the Alt 1B is similar to Alt 2 in general. So, we support Alt1. |
| Xiaomi | For Alt 1B, in our understanding “the UE may assume that the (gNB-)configured application time is after the acknowledgement” does not preclude the case that gNB configured application time is before the acknowledgement. If my understanding is correct, can we change to “the UE may assume that the (gNB-)configured application time is after or before the acknowledgement”? And we can support Alt 1B if my understanding is correct.  {Mod: I don’t believe this is true for Alt1B. It is always after}  Else, we prefer Alt 1A.  We think the difference between Alt 1A and Alt 2 is the TCI state for PDSCH scheduled by the DCI and the HARQ ACK/NACK feedback. As noted by LG, the TCI state in a DCI can apply to the scheduled PDSCH in R15/16 and there is no misalignment between UE and gNB. Thus why not allow UE to apply the TCI state to the scheduled PDSCH before acknowledgement? |
| Docomo | Agree with Apple’s suggestion (But, in that case, it seems we need to change “DCI” into “last symbol of DCI”, because DCI may be on multiple symbols).  If we discuss BAT in next meeting, is it possible to add the following option?   * Alt2B: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication, where the new beam is applied to the PDSCH (scheduled by the beam indication DCI) and corresponding HARQ transmission before updating the unified TCI state.   {Mod: Added with some rewording (also with the threshold rule per Rel.15/16 ) – please check}  Our preference is Alt.2B (1st priority), and Alt. 2 (2nd priority). |
| Ericsson | We do not see the point of Alt1B, and we do not see the relation to other DCI format, so we would propose to make the decision already in RAN1#104-e.  As we stated before, if the NW wants to perform the beam switch before the ACK, that should be up to the NW: the NW would take all aspects into account, both regarding design complexity, speed and risk for beam misalignment. With a DCI format that is robust enough, that risk can be managed, in case a super-fast beam switch is required.  We were thinking about an Alt1C, which utilizes the already agreed UE capability:   * Alt1C: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication   + At least one of the candidate values of the UE capability implies that the beam switch happens after the acknowledgement   With Alt1C, there is a guarantee that the UE is not forced to perform a beam switch before the ACK – the UE would simply advertise a capability that is large enough.  {Mod: Indeed. This will replace Alt1B} |
| vivo | Support Alt2. |
| Sony | We share the same observation from FL that the beam applicable timing also depends on the pending DCI format (e.g. UL DCI or new dedicated DCI) for conveying TCI. So it’s okay to decide the BAT when DCI formats are finalized as predicated in RAN1#105e.  One concern on Alt1B is that if the acknowledgement to scheduled PDSCH or SPS PDSCH release is NACK, then would the BAT still valid? If yes, there might be beam misalignment between NW and UE which is also applicable to Alt.1A in previous email discussion. |
| Nokia | We prefer Alt 2. But can be open for further discussion. |
| Samsung | As comment by several companies we don’t see the value of adding Alt1B. It should be up to the network to decide whether the beam application time is after or before the corresponding HARQ-ACK.  We would like to motivate Alt1A based on the following example:   * Scenario 1: Single transmission of PDSCH: gNB sends PDCCH with TCI state scheduling a PDSCH. There are no other uplink or downlink transmissions before the PUCCH with the corresponding HARQ-ACK. In this case, with Alt1A, the network can set the beam application time to be before the start of the corresponding PDSCH, the UE can apply the new beam to PDSCH – this is already support in Rel-15/16, it would be a pity not to support in Rel-17. There is no misalignment as there are no other uplink or downlink transmissions before the PUCCH with the corresponding HARQ-ACK. This is not possible with Alt2 or Alt1B. * Scenario 2: There are other uplink or downlink transmissions between the time the PDCCH with the TCI state is sent and its corresponding acknowledgement. In this case, the network can choose whether to apply the beam before the acknowledgement and handle the consequences of misalignment, or set a beam application time to be large enough to occur after the acknowledgment, and there will be no misalignment.   With Alt1A, scenarios 1 and 2 are supported and it would be up to the network to set the value of the BAT. |
| OPPO | We suggested another option which shall consider the requirement from both UE and gNB. That option is missing from the proposal:  We suggest to update Proposal 3.1 by adding a Alt3.  **Proposal 3.1**: On Rel.17 DCI-based beam indication, regarding application time of the beam indication: if beam indication is received, down-select (no later than RAN1#105-e) from the following:   * Alt1A: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication * Alt1B: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication   + In addition, the UE may assume that the (gNB-)configured application time is after the acknowledgement * Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication * Alt3: the first slot that is at least X1 ms or Y1 symbols after the DCI with beam indication and X2 ms or Y2 symbols after the acknowledgment of the beam indication. |
| Qualcomm | We are fine for both Alt1-B and Alt2, which have no reliability issue. |
| InterDigital | We prefer Alt2. |
| Lenovo/MoM | We support Alt 2. We think Alt1A is can be replaced by Alt 1B. The down-selection can take place between Alt1B and Alt2. |
| Intel | We are ok with Alt.2.  We do not see a point of Alt 1B since the functionality is same as in Alt 2. Further, based in Apple’s comments, we also believe it is necessary to address from which symbol the time counting is started since the PUCCH resource carrying the HARQ can be multiplexed etc. To this end, we think we should start the count from the first symbol of the PUCCH resource which carries the actual HARQ/ACK information since for some cases like PUCCH with repetition, if the last repetition is dropped, there may be some ambiguity. |
| Intel | We are ok with Alt.2.  We do not see a point of Alt 1B since the functionality is same as in Alt 2. Further, based in Apple’s comments, we also believe it is necessary to address from which symbol the time counting is started since the PUCCH resource carrying the HARQ can be multiplexed etc. To this end, we think we should start the count from the first symbol of the PUCCH resource which carries the actual HARQ/ACK information since for some cases like PUCCH with repetition, if the last repetition is dropped, there may be some ambiguity. |
| Moderator | Since there is no functional difference between the original 1B and 2, I replaced 1B with Ericsson’s proposal. In this case, there is still some room to apply a more aggressive latency requirement in the future via UE capability.  Also added 2B and 3 per companies’ request |
| Huawei, HiSilicon | Proposal 3.1: Given that the offset between DCI and ACK is dynamically indicated by NW, we assume the sub-bullet of Alt-1B implies that one candidate time offset of UE capability reporting will be larger than the ***maximum*** possible time offset between DCI and ACK, which is 47 slots. And we think using RAN1#105-e as deadline (skipping RAN1#104b-e) is somehow kind of too late.  {Mod: Since we have made many agreements to finalize issues by RAN1#104bis-e, I set the date a bit later out of respect for company(ies) who may have some concern that the workload for RAN1#104bis-e is too overwhelming. But observe, I use “no later than”, meaning if it is possible we can agree in RAN1#104bis-e.} |
| Docomo | Support Proposal 3.1. |
| Spreadtrum | We can accept either Alt1B or Alt2A to solve reliability issue. For Alt2B, we think it should be removed, and instead, a new proposal on the TCI applicability of PDSCH (scheduled by the beam indication DCI) and corresponding ACK transmission can be considered after we finish the down-selection. We also suggest to remove Alt1A to narrow down the solutions. |
| LG2 | Support Alt2B and not support Alt2A. For Alt2A, it will increase latency for PDSCH TCI update/indication compared to legacy, which is opposite direction from this WI objective (i.e. overhead and **latency reduction**). |
| MediaTek | Regarding the last bullet of FFS, we think it can be resolved in this proposal. To our understanding, understanding that the BAT is only applied when the newly indicated beam in the beam indication is different from the previously indicated beam. If this is common understanding, main bullet can be update:  **Proposal 3.1**: On Rel.17 DCI-based beam indication, regarding application time of the beam indication: if a beam indication is received and the newly indicated beam in the beam indication is different from the previously indicated beam, down-select (no later than RAN1#105-e) from the following:  {Mod: Added, and I removed the FFS}  Regarding 1B, we share similar view with Huawei. Except UE reports a very large value, how does NW understand that the value reported from UE implies that the beam switch should happens after the DCI or the acknowledgement? The only possible way is using another capability bit to indicate the support of either Alt1 or Alt2A. Then, NW can understand how to configure/assume the BAT for UE. Thus, we suggest one alternative to replace 1B:   * Alt1B: Introduce a UE capability that indicates the support of Alt1 or Alt2A   {Mod: This is a good suggestion. I relabelled this as alternative 2C and added lacrification that both Alt1 and Alt2A are supported in this case.}  Regarding 2B, we have concern on different BATs may cause more reliability issues. Furthermore, we failed to see the need of separate BATs for PDSCHs and other channels/RSs, respectively.  {Mod: We will leave down selection later}  Regarding 3, sorry we are confused. Why do we need two sets of X/Y? According to the wording, basically, no matter what X2/Y2 is, X1/Y1 is useless since application time is always later than the last symbol of the acknowledgment.  {Mod: From OPPO’s explanation, it is because from the UE perspective, BAT is relative to the DCI reception. But a second condition is needed to ensure there is no misalignment from gNB perspective. Reworded to avoid confusion.} |
| Xiaomi | We think Alt 1A, Alt 1B and Alt 2B can support the new beam application for the PDSCH scheduled by the beam indication DCI. But with Alt 1B, it needs to define more candidate X/Y values, and only one of them will be used and indicated to UE. With Alt 2B, both values can be considered together, one is the time offset analogous to Rel.15/16 and another one is X/Y. if the time offset is larger, new beam can be applied to PDSCH. Else, new beam can be applied after acknowledgement. Thus, we prefer Alt 1A and Alt 2B. |
| ZTE | There are too many candidates, and we suggest to remove some of them for the sake of the following down-selection.  From ZTE perspective, we can support Alt-2A, and at least Alt-2B should be removed due to the reason raised by MediaTek.  {Mod: I agree. But this can be done when we are ready to make decision. Per ZTE’s comment, this is done after the DCI format issue is resolved. So we can do this in RAN1#104bis-e or at the latest RAN1#105-e.} |
| Huawei, HiSilicon (2nd batch) | After checking the agreement again, we noticed that in RAN1#103-e, it was agreed to down-select between Alt-1 and Alt-2 (without ‘modify from’). In this meeting, three more alternatives are added on table, which may not help making progress. In general, we suggest honoring the agreement in RAN#103-e and make decision between Alt-1 and Alt-2 directly. |
| InterDigital | We support MTK’s proposal.  {Mod: Added, and I removed the FFS} |
| Samsung2 | To better understand Alt2B, this requires the UE to apply the new beam to PDSCH and possibly PUCCH before the beam switch time, and all other channels have the new beam applied after the beam switch time (which is X ms after the corresponding PUCCH). In this case, we think that there should be a first beam switch time for PDSCH, i.e. the new beam is applied to PDSCH if PDSCH is X1 ms after the corresponding DCI (same as Rel-15), and the new beam is applied to all other channels after X2 ms after the corresponding PUCCH.  For Alt3 what is the motivation for defining 2 timelines?  {Mod: Please see my explanation to MediaTek. OPPO can elaborate more} |
| Lenovo/MoM | We think this proposal now has too many alternatives to make the selection more difficult. We suggest to remove Alt1A and Alt3. The reason is the additional condition in Alt1B is necessary to satisfy the beam switching time. This makes Alt1B is more complete and correct version of Alt1A. Alt3 is too complicated compared with Alt1B or Alt2B. The timing requirement of Alt3 is actually the same as Alt1B and Alt2B, so Alt3 is redundant. The down selection shall be between Alt1B and Alt2B.  {Mod: We will do so when down-selection is done. I tried but companies voiced concern when I tried to remove certain alternatives. Same as the agreement on additional DCI formats ☺} |
| Qualcomm | For Proposal 3.1, support Alt1B and Alt2A.  Alt1A and Alt2B may have beam switch misalignment issue to our understanding, since the application time can happen before the acknowledgement  Not clear the motivation/meaning of Alt3 |
| Moderator | Proposal 3.1 is revised.  @OPPO: I have tried to explain questions re Alt3. If you can elaborate please. |
| OPPO2 | Re the questions on Alt3:  @Samsung: we are not defining two timeline. There is still one timeline but use two conditions to determine one time point. The reason for that is we need to consider the process time requirement from both sides: UE and gNB. Look at the following example. Assume one DCI indicating TCI is received at slot n and the ack to the TCI indication is sent at slot n+m:     * At the UE side: the minimum time the UE needs to switch to the new TCI state include: a time used to decode the DCI and a time used to prepare the new Rx beam (or even including activating the new Rx panel). So the earliest time point when the UE can switch to the new TCI state is X1 after the DCI. * At the gNB side: the gNB switch to new TCI state only after receives the ack from the UE. The time length the gNB needs include (1) the time decode the ACK and (2) the time used to switch the Tx beam. Overall, the earliest time point that the gNB can apply the new Tx beam is X2 after the ack.   The TCI state switch shall satisfy both requirements so that both sides are ready for the new TCI state. herefore, the earliest time point when both gNB and UE can switch to the new Tx beam/TCI state is the time point that can meet both conditions:   * Condition 1: at least X1 ms after the DCI, which is the UE capability. * Condition 2: at least X2 ms after the ack, which considers the gNB requirement.   That is why we propose to Alt3 for study.  @ Lenovo/MoM: Alt3 are different from Alt1B and Alt 2B. Alt1B only consider the requirement from the UE side. And Alt2B is not correct technically because it allows the UE to switch to the new TCI state even before the acknowledge is received by the gNB, which is not correct in our view. The new common TCI state can be applied after both UE and gNB are ready for the new TCI state. Just as we explained above, only when both condition 1 and condition 2 are meet, both sides are ready for the new TCI states. |
| Intel | There was a previous agreement to down-select between Alt 1 and 2 but now somehow we have more than 2 options on the table where Alt. 3 is a new option. We should only be debating the original alternatives without adding new ones! We can be ok with Alt 1, 2A and 2B (see discussion below) at most.  {Mod: I sympathize with your comments. Since we are not yet down selecting, I cannot refuse companies’ request to list their additional alternatives. Some are made as an effort for possible compromise. Other are based on additional observations. But to address your concern (shared by me ☺) I added tha no more alternatives will be considered.}  Alt. 3 seems quite complicated i.e., we are defining things from both network and UE perspective which seems unnecessary. The issue of misalignment can be handled by Alt 2. Since both gNB and UE can align on beams only after gNB receives the ACK, it should be enough to apply BAT from ACK transmission.  {Mod: Please bring this up when down selection is done.}  On Alt 2B, is the intention that when DCI schedules a PDSCH, in addition to beam indication, the indicated beam should be applicable to the PDSCH reception provided it’s after threshold? If yes, then this is Rel-16 behavior but to apply the new beam also to the PUCCH for ACK is new behavior. If ACK uses new beam, we do not get how it is used as an ACK for the beam indication where the UE is already using the beam that was indicated. This is like a chicken-and-egg problem. In our understanding, Alt 2B can be sub-divided into cases where, for DCI without DL assignment, if supported, follows Alt. 2 i.e., BAT is counted from PUCCH carrying ACK; and for the case when DCI carries a DL grant, only the PDSCH beam is updated to the new beam after threshold and the BAT still applies to other channels after ACK is transmitted.  {Mod: Please bring this up when down selection is done.}  Our preference is Alt. 2 A with the following update:   * Alt2A: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the PUCCH resource carrying the acknowledgment of the joint or separate DL/UL beam indication   {Mod: Done} |
| Moderator | Proposal 3.1 is revised per Intel’s inputs. |
| Sony2 | Proposal 3.1 looks good to us.  In the main bullet, we see the condition that “if beam indication is received”, does it mean a UE successfully decodes a DCI which carried TCI for beam indication? If yes, should we also discuss the case that “the beam indication is not received” It seems both cases can make a whole picture of beam indication.  As for Alt.3, we understand it as max{Alt1, Alt2A} which may result in longest beam application time. If yes, from latency perspective, it seems not a desirable candidate. |
|  |  |
| Docomo | Support the proposal to down select in the next meeting. We support Alt. 2B. The reason is Alt. 2A can avoid beam miss-alignment issue b/w gNB and UE (which we believe better than Alt. 1), however, the latency of the beam application becomes larger than Rel.15/16 (e.g. the beam indication DCI cannot indicate the new beam for the scheduled PDSCH). On the other hand, in Alt. 2B, the new beam can be applied to the scheduled PDSCH (same as Rel.15/16) and corresponding HARQ transmission. Since PDSCH reception and HARQ transmission is only happened when UE can decode the scheduling DCI (which also contains new beam indication), there is no miss-alignment issue in this case. So, the Alt.2B is good compromised solution between Alt.1 and Alt. 2A. Some companies seems to have concern to apply the new beam to HARQ transmission before the beam application time, however, if UE miss the beam indication DCI, UE shall not transmits HARQ. Please note that there is only following two cases:   1. If UE can detect the beam indication DCI, UE transmits HARQ-ACK in new beam 2. Else, UE does not transmit HARQ-ACK   So, gNB is only required to receive HARQ ACK in the new beam. If gNB does not receive the HARQ ACK, gNB can re-send the beam indication DCI in old beam. The miss alignment issue does not happen in Alt. 2B.  For Intel’s comment, we agree there may be the case the beam indication DCI has no DL assignment (depending on the discussion of new DCI format), we suggest to add following.   * Alt 2B: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication, except that the (new) TCI state update can be applied to the PDSCH, if exist, (scheduled by the beam indication DCI) and corresponding ACK transmission (provided that the time offset between the DCI and the scheduled PDSCH exceed the threshold, analogous to Rel.15/16) |
| MediaTek | It is good to have the sentence “No other alternatives will be considered”. Support!  One minor change. Should we also add “[first/last] symbol of” before DCI in Alt1 and Alt3? |